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Atmosphere of SN 1987A in the Large Magellanic Cloud

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Principal Investigator: Robert P. Kirshner
Harvard College Observatory MS-19
60 Garden Street
Cambridge, MA 02138
(617) 495-7519

Robert Kirshner

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SUMMARY OF RESULTS

This program supported the analysis of IUE observations of supernovae. One aspect was a Target-of-Opportunity program to observe bright supernovae which was applied to SN 1993J in M81, and another was continuing analysis of the IUE data from SN 1987A. Because of its quick response time, the IUE satellite has continued to provide useful data on the ultraviolet spectra of supernovae. Even after the launch of the Hubble Space Telescope, which has much more powerful ultraviolet spectrometers, the IUE has enabled us to obtain early and frequent measurements of ultraviolet radiation: this information has been folded in with our HST data to create unique observations of supernova which can be interpreted to give powerful constraints on the physical properties of the exploding stars. Our chief result in the present grant period was the completion of a detailed re-analysis of the data on the circumstellar shell of SN 1987A.

The presence of narrow high-temperature mission lines from nitrogen-rich gas close to SN 1987A has been the principal observational constraint on the evolution of the supernova's progenitor. Our new analysis shows that the onset of these lines, their rise to maximum, and their subsequent fading can be understood in the context of a model for the photoionization of circumstellar matter.

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The Evolution of Ultraviolet Emission Lines From Circumstellar Material Surrounding SN 1987A

George Sonneborn[1], Claes Fransson[2], Peter Lundqvist[2], Angelo Cassatella[3], Roberto Gilmozzi[4], Robert P. Kirshner[5], Nino Panagia[6,7,8], and Willem Wamsteker[9]

ABSTRACT

The presence of narrow high-temperature emission lines from nitrogen-rich gas close to SN 1987A has been the principal observational constraint on the evolutionary status of the supernova's progenitor. We present a new analysis of the complete five-year set of low resolution *IUE* ultraviolet observations of SN 1987A (1987.2–1992.3). The fluxes for the N V λ1240, N IV] λ1486, He II λ1640, O III] λ1665, N III] λ1751, and C III] λ1908 lines were measured using new techniques which significantly reduce random and systematic errors. The sudden turn-on of the lines occurs at 83 ± 4 days after the explosion, as defined by N IV]. The N V, N IV], and N III] lines turn on sequentially over 15 to 20 days and show a progression from high to low ionization potential, implying an ionization gradient in the emitting region. The N III] line reaches peak luminosity at 399 ± 15 days. The probable role of resonant scattering in the N V light curve introduces systematic errors that exclude this line from the analysis of turn-on and maximum times. The light curve morphology is that

[1]Laboratory for Astronomy and Solar Physics, Code 681, NASA/Goddard Space Flight Center, Greenbelt, MD 20771; sonneborn@fornax.gsfc.nasa.gov

[2]Stockholm Observatory, S-133 36 Saltsjöbaden, Sweden.

[3]Istituto di Astrofisica Spaziale, CNR, CP 67, I-00044 Frascati, Italy.

[4]European Southern Observatory, Karl-Schwarzschild Str. 2, 85748 Garching bei München, Germany.

[5]Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138.

[6]Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218.

[7]Affiliated with the Astrophysics Division, Space Sciences Department of ESA.

[8]On leave from the University of Catania.

[9]*IUE* Observatory, ESA-VILSPA, Casilla 50727, E-28080 Madrid, Spain.

expected from a toroidal geometry. From the times of turn on and maximum line strength we derive a ring radius of $(6.24 \pm 0.20) \times 10^{17}$ cm and inclination of $41\overset{\circ}{.}0 \pm 3\overset{\circ}{.}9$, which correspond to a LMC distance of 48.6 ± 2.2 kpc. A new nebular analysis yields improved CNO abundance ratios N/C$= 6.1 \pm 1.1$ and N/O$= 1.7 \pm 0.5$, confirming the nitrogen enrichment found in our previous paper. The late-time behavior of the light curves, particularly N V, implies a multi-component density structure of the emitting region. We estimate the emitting mass around day 400 to be $\sim 4.7 \times 10^{-2} M_{\odot}$, assuming a filling factor of unity and an electron density of 2.6×10^{4} cm^{-3}. The observations are discussed in the context of current models for the emission and hydrodynamics of the ring.

Subject headings: Stars: Circumstellar Material — Supernovae: General — Supernovae: Individual(SN 1987A) — Ultraviolet: Spectra — Methods: Data Analysis